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(54) Ice detector

(57) An ice detector which avoids false readings, eg due to snowflakes, comprises a duct 10 which may be attached to a helicopter body by a stand 12, an electrically conductive probe bar 16 across the duct, and pairs of diametrically opposed light emitters 20 and sensors 21. In icy conditions, ice accretes on the probe 16, progressively blocking the light reaching sensors 21, and the interval between the sensor output crossing an upper and a lower threshold is used to provide an indication of the icing conditions. The sensor output is sampled at short intervals during accretion, and if any sample differs from the previous one by more than predetermined step, this is interpreted as a momentary reduction, eg due to a snowflake, and ignored. After the sensor output has fallen below the lower threshold, the probe is heated to melt the ice to allow repetition of the measurement. Air from a nozzle 14 may draw air through the duct 10 by the venturi effect.

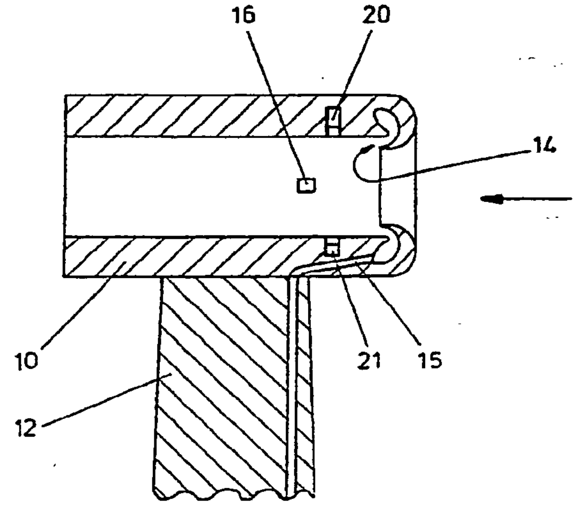

FIG. 1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1990.

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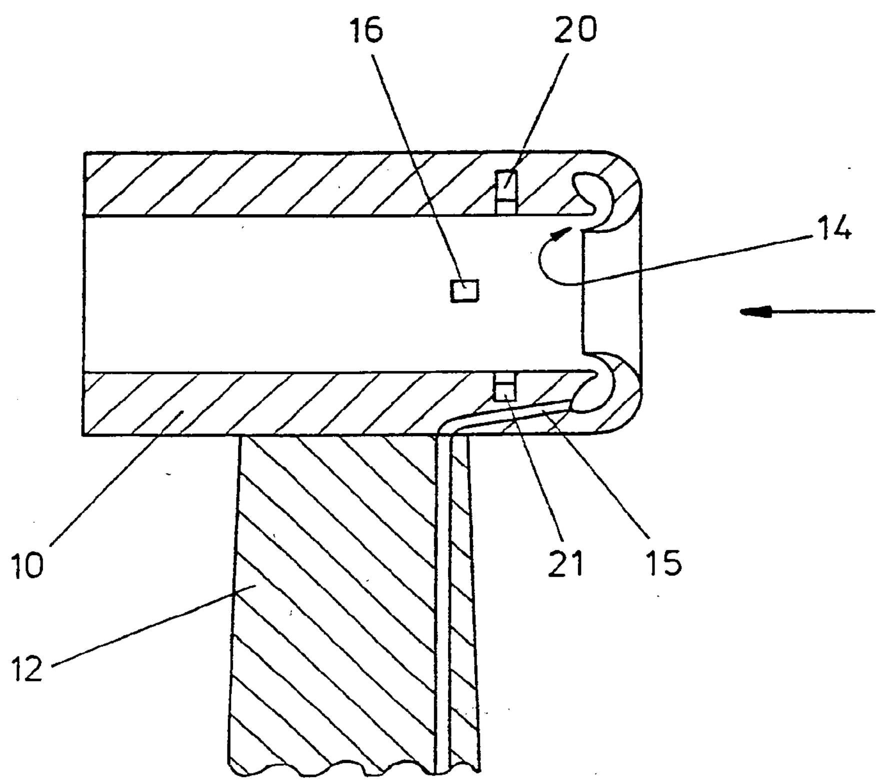

FIG. 1

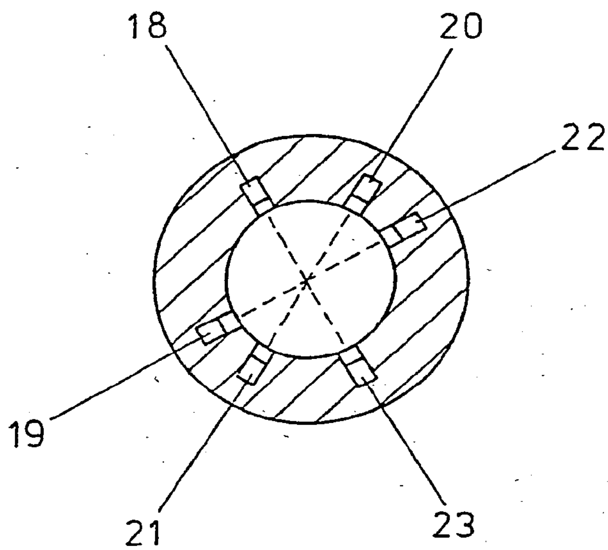

FIG. 2

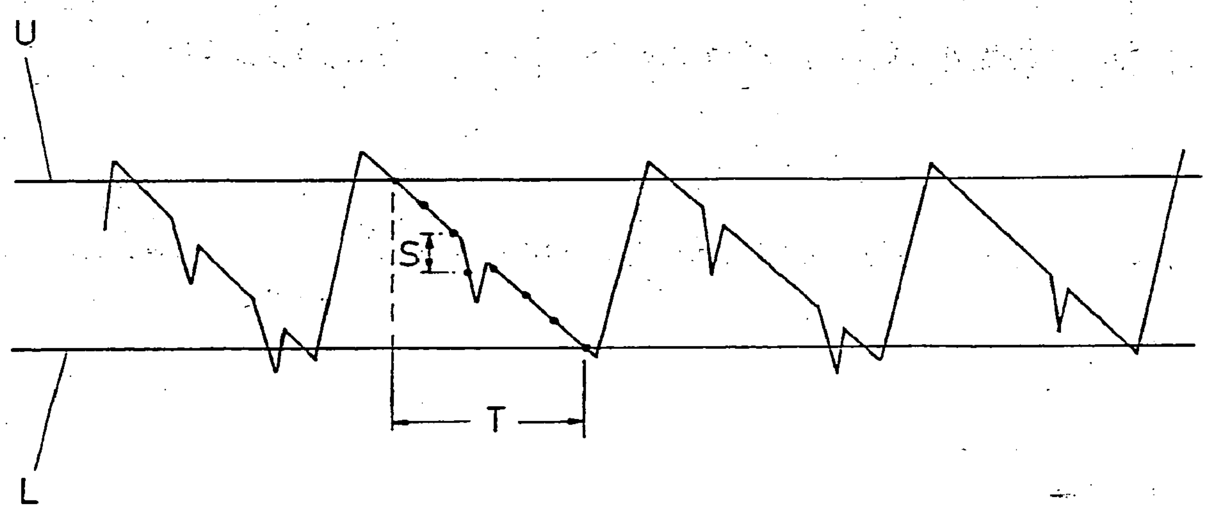

FIG. 3

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Ice Detector

This invention relates to an ice detector, and more particularly to a combined ice and snow detector which is for use particularly (but not solely) on helicopters and other aircraft.

An ice detector is particularly vital for a helicopter, because of the dangerous consequences of ice building up on the rotor blades. A common form of ice detector is disclosed in GB-1406957, and comprises a duct through which ambient air is drawn, a probe in the form of an electrically conductive bar extending across the duct, and a light emitter and light sensor mounted in diametrically-opposed bores in the duct, to define a light path inclined to air partially obscured by the probe.

In use of the ice detector of GB-1406957, and under icy conditions, ice builds up (or accretes) gradually on the leading edge of the probe, and progressively obscures the light path between the light emitter and light sensor, such that the output signal of the light sensor progressively diminishes. When the light sensor output signal falls below a minimum threshold value, an electrical current is passed through the probe in order to heat it: this quickly melts the ice which has built up on the probe, and as a result the light sensor output signal rises quickly to a high value. The electrical heating current is then switched off, enabling ice to build up again on the probe, until the light sensor output again falls below its minimum threshold to switch the heating current on again. This cycle repeats indefinitely whilst the conditions remain icy.

The detector measures the time taken, on each cycle, for the light sensor output signal to fall from an upper threshold value (just after the removal of the heating current) to the minimum or trigger threshold value. These time measurements give an indication of the amount of water in the ambient air, and can be used, for example to drive an indicator calibrated according to the mass of water per unit volume of air, or liquid water content (e.g. grammes per cubic metre).

A problem with the above-described ice detector is that, in the presence of light snow, occasional snow flakes

will pass through the detector duct and in so doing may momentarily interrupt the light path between the light emitter and sensor: this momentarily reduces the light sensor output signal, and can thus reduce the light sensor output signal below its minimum threshold, so triggering application of the probe heating current. When this happens, an artificially low measurement is recorded for the time taken for the light sensor output signal to drop from its upper threshold to its trigger threshold, therefore giving an erroneously high indication of the amount of water present in the ambient air.

In accordance with this invention, there is provided an ice detector which comprises a probe, a light emitter and a light sensor forming a light path which becomes progressively obscured as ice builds up on said probe, means for heating the probe to melt the ice thereon in response to an output signal of said light sensor indicating that the light received by that sensor is below a minimum threshold value, and means for determining the time taken for said output signal to fall from an upper threshold value but independently of any momentary reductions in said output signal.

Accordingly, this detector is arranged to ignore any momentary reductions in the light sensor output signal, which are due to snow flakes momentarily obscuring the light path.

Preferably a control system of the detector samples the light sensor output signal at predetermined intervals of time: if any sample differs from the immediately preceding sample by greater than a predetermined step, this is interpreted as a momentary reduction due to a snow flake and ignored if it takes the light sensor output signal below the minimum threshold.

The detector in accordance with this invention therefore determines the time taken for the light sensor output signal to fall from the upper threshold value, ignoring the spurious effects of snowflakes.

However, the detector control system preferably also counts per unit time the occurrences that successive samples of the light sensor output signal differs by greater than the predetermined step. The value of this count indicates the severity of the prevailing snow (which may be classified as

NONE, TRACE, LIGHT, MODERATE or SEVERE).

Preferably the detector in accordance with this invention comprises a plurality of light emitters and corresponding light sensors, forming a plurality (preferably three) channels: in each of these, a measure is made of the time taken for the light sensor output signal to fall from the upper threshold to below the minimum threshold, independently of any momentary reductions in the output signal. These measured times are then averaged over the plurality of channels. The probe is not heated to melt the ice accreted thereon until the last of the light sensor signals has fallen below the minimum threshold, providing all these signals fall below the minimum threshold within a predetermined time.

Preferably the control system of the detector is arranged to test the plurality of channels for reliability, particularly in case any of the light emitters or sensors becomes occluded by dirt etc. Thus, after the heating phase of the probe, each light emitter is energised to different light intensity levels in succession and the corresponding output signals of its light sensor are recorded: if these are within predetermined limits, the corresponding light channel is passed as being reliable or "good". Over those channels which are found to be "good", an average is formed of the times taken for the respective light sensor output signals to fall from the upper to the minimum threshold values.

An embodiment of the invention will now be described by way of example only and with reference to the accompanying drawings, in which:

FIGURE 1 is a diagrammatic longitudinal section through an ice and snow detector in accordance with this invention;

FIGURE 2 is a diagrammatic cross-section through the detector of Figure 1; and

FIGURE 3 is a waveform diagram schematically showing the variation in output signal of a light sensor of the detector.

Referring to Figures 1 and 2, an ice and snow detector in accordance with this invention comprises a tubular duct 10 mounted on a stand 12 for fixing to the exterior of a

helicopter, for example. A venturi arrangement is provided for drawing ambient air through the duct 10 in the direction of the arrow, even when the helicopter is stationary: this venturi arrangement comprises, for example, an annular nozzle 14 on the inside of the duct 10 adjacent its front end and directed rearwardly; in use air is blown along a passage 15 and out of the nozzle 14 to draw ambient air through the duct 10. The detector also comprises an ice probe in the form of an electrically conductive bar 16 mounted diametrically across the duct 10. Three separate, diametrical light paths are also formed, just forwardly of the probe 16, by three infra red light emitters 18,20,22 and corresponding light sensors 19,21,23 mounted in radial bores formed in the duct 10. As shown in Figure 2, the three light paths lie at different angles of inclination to the probe 16.

Figure 3 shows a typical variation of the output signal of any one of the light sensors, under icy conditions. Thus, as ice builds up on the forward edge of the probe 16, the output signal of the light sensor gradually reduces. When this output signal falls to a minimum threshold L, an electric current is switched on through the probe 16 to heat this and melt the ice: the light sensor output signal quickly rises to a maximum value. The time T is recorded, i.e. the time taken for the light sensor output signal to fall from a predetermined upper threshold U to the minimum threshold L, as a measure of the amount of liquid water in the atmosphere. However, in the presence of light snow, occasional snow flakes will pass through the duct 10 and momentarily interrupt the light path, causing a momentary or spike-like reduction in the light sensor output signal: as shown in Figure 3, such a spike can take the light sensor output signal below the minimum threshold L, causing an erroneously short value of time T to be recorded, and therefore giving an incorrect indication of the amount of ice in the atmosphere.

The detector in accordance with this invention includes a microprocessor which measures the output signal of each of the three light sensors at equal intervals of time. Each such measurement is compared with the immediately preceding

measurement for the same light sensor: if the reduction in the output signal is greater than a predetermined step S, this is interpreted as being caused by a snow flake passing through the duct 10 and momentarily interrupting the corresponding light path. If the new measurement is below the trigger threshold L, it is ignored, and the system waits until a subsequent measurement (itself not indicating a snow flake) is below the trigger threshold L, before the time T is recorded.

The time periods T for all three optical channels are recorded (T1,T2,T3) and averaged to provide an indication of the amount of ice in the atmosphere. The electric heating current to the probe is switched on when the last of the three sensor output signals passes below the trigger threshold L. However, the detector control system tests whether all three optical channels are effective, in case the light emitter or light sensor of any channel should become obscured by dirt etc. Thus, immediately after the probe heating current is switched off, each light emitter is energised to different light intensity levels in succession, and the output signal values of its light sensor are recorded: if these recorded values are found to be within predetermined limits, then the corresponding light channel is passed as being effective or "good". If only two light channels are found to be "good", then the times T for those two channels are averaged: if only one light channel is found to be "good", then the measured times T for that channel only are taken into account, and the control system gives an indication that the detector requires maintenance (which can be carried out next time the helicopter is on the ground).

The detector which has been described is thus able to provide a reliable indication of the amount of water in the atmosphere, unaffected by the presence of snow flakes. Moreover, the detector gives an indication of the amount of prevailing snow: for this purpose, the control system counts the number of times successive measurements of each light sensor output differ by greater than the predetermined step S; the count per unit time of these occurrences is used to indicate the level of snow as NONE, TRACE, LIGHT, MODERATE or SEVERE.

Claims

1) An ice detector which comprises a probe, a light emitter and a light sensor forming a light path which becomes progressively obscured as ice builds up on said probe, means for heating the probe to melt the ice thereon in response to an output signal of said light sensor indicating that the light received by that sensor is below a minimum threshold value, and means for determining the time taken for said output signal to fall from an upper threshold value but independently of any momentary reductions in said output signal.

2) An ice detector according to claim 1, which further comprises a control system for sampling the light sensor output signal at predetermined intervals of time.

3) An ice detector according to claim 2, wherein said control system is arranged to disregard and sample if said sample differs from an immediately preceding sample by greater than a predetermined step such that the light received by the sensor falls below said minimum threshold.

4) An ice detector according to claim 3, wherein the detector control system is arranged to count per unit time the occurrences that successive samples of the light sensor output signal differ by greater than said predetermined step.

5) An ice detector according to any preceding claim, which comprises a plurality of light emitters and corresponding light sensors, forming a plurality of channels.

6) An ice detector according to claim 5, comprising three said channels.

7) An ice detector according to claims 5 or 6, wherein said control system is arranged to measure, for each of said plurality of channels, the time taken for the light sensor output signal to fall from the upper threshold to below the

minimum threshold, independently of any momentary reductions in the output signal.

8) An ice detector according to claim 7, wherein said control system is arranged to average each of said measured times over said plurality of channels.

9) An ice detector according to claim 8, arranged such that said means for heating said probe is not actuated until all of the light sensor output signals in each of said plurality of channels has fallen below said minimum threshold, providing all of said signals fall below said minimum threshold within a predetermined time.

10) An ice detector according to any of claims 5 to 9, wherein said detector control system is arranged to test said plurality of channels for reliability.

11) An ice detector according to claim 10, wherein said control system is arranged so that, after each time the probe has been heated, each light emitter is energised to a different light intensity level and to record the corresponding output signals of the light sensors, such that if said recorded output signals are found to be within predetermined limits, said light channels are passed as being reliable.

12) An ice detector according to claim 10, wherein said control system is arranged to form an average of the times taken for respective light sensor output signals of channels found to be reliable fall from the upper threshold value to the minimum threshold value.

13) An ice detector as herein described with reference to the accompanying drawings.

8

Patents Act 1977 **Examiner's report to the Comptroller under Section 17** **(The Search report)**	Application number GB 9322442.6
Relevant Technical Fields (i) UK Cl (Ed.M) G1A (AMP, AMZ) (ii) Int Cl (Ed.5) G08B 19/02	Search Examiner R S Clark Date of completion of Search 6 September 1994
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE DATABASE : WPI	Documents considered relevant following a search in respect of Claims :- All

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Category	Identity of document and relevant passages	Relevant to claim(s)
	NONE	

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